52. IWK

Internationales Wissenschaftliches Kolloquium

International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME II

TECHNISCHE UNIVERSITÄT ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

7 New Methods and Technologies for Medicine and Biology

8 Embedded System Design and Application

10 Mobile Communications

11 Education in Computer Science and Automation

52nd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10 – 13 September 2007

S. Bauer / T. Döring / F. Meysel / R. Reulke

Traffic Surveillance using Video Image Detection Systems

ABSTRACT

The use of non-intrusive video-detection for traffic flow observation and surveillance is the primary alternative to the conventional inductive loop detector. A Video Image Detection System (VIDS) can derive traffic parameters by means of image processing and pattern recognition methods. Classic systems like inductive (double) loops or microwave radar detectors are able to measure presence and length of a vehicle as well as speed and time gap to the preceding vehicle. Existing VIDS emulate the inductive loop by virtual loops and derive the traffic parameters in a similar way. Additional benefits of the VIDS, e.g. large area observation of traffic flow or detection of special behaviors of single vehicles can not be exploited in this way. To expand the common approach for new types of information (queue length or erratic movements), we use a trajectory based recognition algorithm, which is related to the detection and tracking of individual vehicles in an image sequence. As an essential application for this algorithm it will be demonstrated how the usual characteristic traffic parameters can be derived from the measured trajectories. This facilitates a direct comparison between the video based and the classic inductive loop measurement of the traffic parameters.

INTRODUCTION

An intelligent traffic management is based on exact knowledge of the traffic situation. Traffic monitoring of roads and intersections is therefore an essential prerequisite for the implementation of an Intelligent Transportation System (ITS). The most common detection and surveillance systems to measure traffic flow on public roads are inductive loops and microwave radar systems. The analysis and comparison of different sensors is found in [17]. In the last 15 years VIDS using real time image processing [1, 2, 3, 14, 15] became more attractive. Besides traditional parameters like presence, vehicle length, speed and time gap between two vehicles they can also determine congestion length, source-destination matrices, blockage or accidents and estimate travel times [6, 7, 8, 9]. This paper is organized as follows: After an overview of existing VIDS, the approach is introduced. An example installation is then described and the results for this installation are presented. The article concludes with a summary and an outlook.

COMMERCIAL VIDEO DETECTION SYSTEMS OVERVIEW

There is already a variety of commercial VIDS available. Details of selected commercial VIDS can be found in Table1.

Supplier	Product	Detection Features
Traficon **http://www.traficon.com/**	VIP/P	vehicle count, queue length measurement
	VIP/D	vehicle count, speed, occupancy, classification, gap time, headway
	VIP/I	stopped vehicle, wrong-way drive, pedestrians, lost cargo, smoke / fire, queue, speed reduction
Image Sensing Systems **http://www.imagesensing.com/**	Autoscope RackVision	vehicle count, vehicle length classification, speed, occupancy time, gap time, congestion, accident, wrong way drive
Aimetic **http://www.aimetis.com/**	AIRA 2005	automatic detection and tracking, object classification, automatic pin / tilt / zoom, unauthorized movement in target zones

Table 1: Commercial VIDS for traffic detection and surveillance

These systems usually provide reliable traffic parameters according to the specifications but also lack the versatility for changing requirements on the surveillance system. For instance, limitations from measurement principles in the spectral or spatial range can be compensated, if complementary sensor systems are combined [10]. Examples are the combination of sensors for visible and infrared radiation or the use of several cameras with different views to cope with occlusions caused by buildings, traffic signs, trees, or cars [16]. Another trend is to combine the traffic object data with image information and geo-coded object description to get a user-friendly traffic characterization with GIS tools [18].

APPROACH

The approach presented here can be separated into four steps (Figure 1). Firstly, all moving objects have to be extracted from each frame of the surveillance video sequence. Then these traffic objects have to be projected onto a geo-referenced world plane, tracked in the sequence and thus will be associated with trajectories. Next, those have to be evaluated to compute the predefined traffic parameters. The four steps shall be described more precisely in the following.

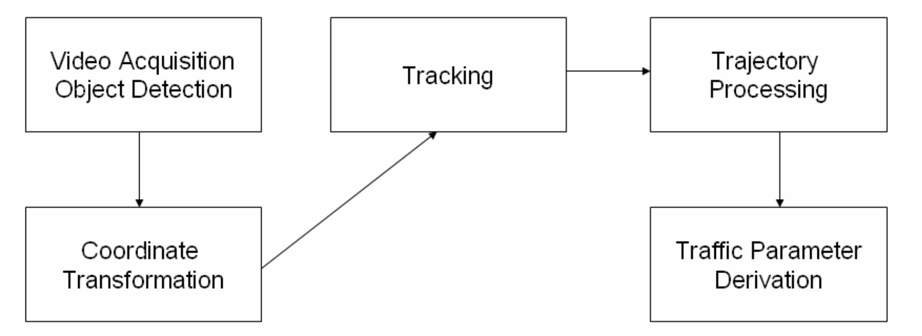

Figure 1: Process chain

1. Video Acquisition and Object Detection

Only digital camera systems are considered. To receive a reliable and reproducible result, only compact industry cameras are used. In addition, only widespread interfaces and protocols (e.g. IEEE1394, Ethernet) are used for the data transmission.

In order to extract the traffic objects from an image sequence, different image processing libraries or programs (e.g. OpenCV or HALCON) can be utilized. Here the development environment HALCON was used. HALCON provides easy access to different image sources and a large software library for standard computer vision tasks. An already implemented Kalman based background estimator adapts to the variable background and generates a difference image with the searched traffic objects. The extracted objects (Figure 2) in the image are then grouped using a cluster analysis combined with additional filters that incorporate scene knowledge. Such knowledge can be the maximum or minimum traffic object size or the possible position of occurrence. Typical errors of such an approach are e.g. ghosts and shadows [11,12,13].

Figure 2: (a) Grabbed Image (b) Extracted objects

2. Coordinate Transformation and Camera Calibration

The existing tracking concept is based on extracted objects, which are geo-referenced to a world coordinate system. Therefore, a transformation between coordinates of a camera-image to the world coordinate system is necessary. Using collinearity equations the world coordinates can be derived from image coordinates. Additional necessary input parameters are interior and exterior orientation of the camera. The interior orientation (principal point, focal length and additional camera distortion) can be determined by using a well known lab test field. The 10 parameter Brown camera model [19] was used for describing interior orientation. Calculating the exterior orientation of a camera in a well known world coordinate system is based on previously measured ground control points (GCPs) with differential GPS. The accuracy of the points is within the range of less than 5 cm. With these coordinates an approximate orientation can be deduced using DLT [20]. Then the exterior orientation is calculated with the spatial resection algorithm. The lateral error in X- and Y-direction achieved by this approach is 20 cm in 100m distance from projection centre.

3. Tracking and Trajectory Creation

The tracking algorithm is supposed to provide object data information combined in a so-called state vector with respect to time. The state of an object can be described with position, velocity and acceleration in X-, Y- and Z-direction. Features like form, size and color can be added. The first task is the object identification in a video sequence by its predicted state vector. This is done by observation-object-association [14,15]. The tracking of a single object was realized with a Kalman-filter. It estimates the state of an object for the time stamp of the following picture, thus allowing the estimated state and the observed object data to be compared. If both are within a certain feature space distance they can be associated to the same object. An important problem is the initialization of the Kalman-filter. The trajectories are then submitted to the analysis module as soon as they are created for the derivation of traffic parameters (TP).

4. Traffic Parameters Derivation and Data Structures

Incoming trajectories are processed and used for the computation of traffic parameters by a separated module in this approach. The procedure for handling the trajectories is essentially organized in two nested loops, an inner loop for the analysis of each submitted trajectory, and an outer loop that aggregates and updates traffic parameters for a time cycle with the analysis results of each trajectory. In the inner loop the trajectories are compared to detector structures, defined in world coordinates. Here these structures are line detectors or area detectors, placed in the scene. For each trajectory, the set of detector structures is tested for trajectory-detector interaction and the results are saved. The testing is done for each trajectory by interpolating the object positions between discrete moments and finding intersection of detectors and trajectory interpolation between pairs of points in space. For a positive test, the detector stores the interpolated spatial coordinates of the intersection and the interpolated moment of activation. It will hold this data until it is queried from within the inner loop. At the end of the inner loop, detector activations are queried and sorted by time. For multiple activations, trajectories are detected, that passed multiple detectors. After a certain time interval has elapsed, the outer loop reads out the advanced traffic parameter data structures. Also all detectors' long-time memories are queried and interpreted for the derivation of integrated cycle parameters.

FIRST RESULTS

The described approach has been implemented and tested on a traffic intersection in Nurnberg, Germany. While the observation conditions were often not agreeable, the object detection still provided enough objects for the processing chain. The coordinate transformation, multi-object-tracking and trajectory creation worked together on a designated PC. Trajectories have been sent to remote computer for the analysis and computation of traffic parameters. The results are promising. Incoming trajectories were evaluated and traffic parameters computed. The trajectories could be visualized in real-time (Figure 3 left) and the current situation could be described by means of the derived traffic parameters. The update cycle for advanced parameters was chosen as one minute. In each interval, activation counts combined with speed information and new source destination matrices have been filled and evaluated. For example, Figure 3 (right) shows a comparison of computed and manually obtained vehicle counts.

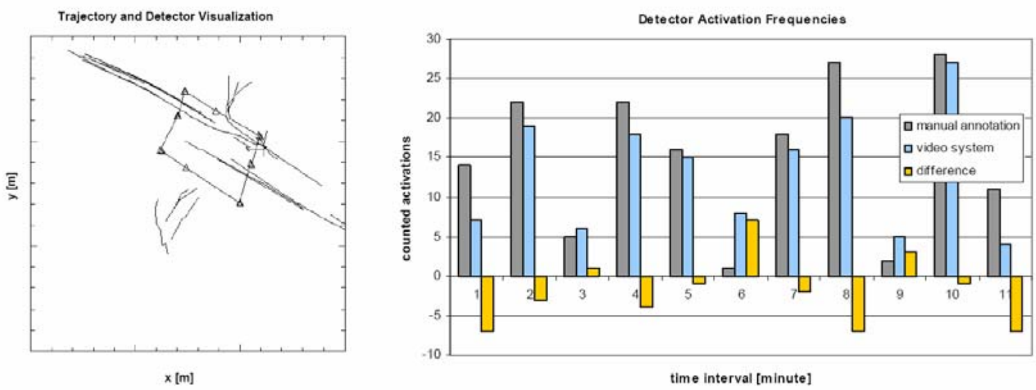

Figure 3: (left) example trajectories in world coordinate system, (right) example count results of one detector

These first results are already very successful. Nevertheless, due to occlusions caused by the observation position the precision is not convincing.

CONCLUSION AND OUTLOOK

The presented approach for a traffic surveillance system has been implemented and tested. Thus, it could be shown that standard traffic parameters can be derived based on video detection, tracking and trajectory analysis. This step is essential on the way to future traffic surveillance systems. Still, the robustness of the processing chain needs to be improved. Accumulated data is not very much affected by small errors. However, detection errors and tracking problems can deteriorate the trajectory data and lead to less usable trajectories for analysis or less reliable traffic parameters. Methods to recognize object detection errors and deteriorated trajectories to stitch them together correctly as well as deriving new traffic parameters are key factors for current and future work.

References:

[1] Michalopoulos, P.G., (1991). Vehicle Detection Video through Image-Processing - the Autoscope System, *IEEE Transactions on Vehicular Technology*, vol. 40(1), pp. 21-29.

[2] Wigan, M.R., (1992). Image-Processing Techniques Applied to Road Problems, *Journal of Transportation Engineering-Asce*, vol. 118(1), pp. 62-83.

[3] Kastrinaki, V., Zervakis, M., and Kalaitzakis, K., (2003). A survey of video processing techniques for traffic applications, *Image and Vision Computing*, vol. 21(4), pp. 359-381.

[4] Kan, W.Y., Krogmeier, J.V., and Doerschuk, P.C., (1996). Model-based vehicle tracking from image sequences with an application to road surveillance, *Optical Engineering*, vol. 35(6), pp. 1723-1729.

[5] Morita, T., (1999). Tracking vision system for real-time motion analysis, *Advanced Robotics*, vol. 12(6), pp. 609-617.

[6] Datta, T.K., Schattler, K., and Datta, S., (2000). Red light violations and crashes at urban intersections, *Highway and Traffic Safety: Engineering, Evaluation, and Enforcement; Trucking and Motorcycles*, (1734), pp. 52-58.

[7] Harlow, C. and Wang, Y., (2001). Automated accident detection system, *Highway Safety: Modeling, Analysis, Management, Statistical Methods, and Crash Location*, (1746), pp. 90-93.

[8] Setchell, C. and Dagless, E.L., (2001). Vision-based road-traffic monitoring sensor, *Iee Proceedings-Vision Image and Signal Processing*, vol. 148(1), pp. 78-84.

[9] Yung, N.H.C. and Lai, A.H.S., (2001). An effective video analysis method for detecting red light runners, *IEEE Transactions on Vehicular Technology*, vol. 50(4), pp. 1074-1084.

[10] Harlow, C. and Wang, Y., (2002). Acoustic accident detection system, *Its Journal*, vol. 7(1), pp. 43-56.

[11] Cucchiara, R., Grana, C., Piccardi, M., and Prati, A., (2003). Detecting moving objects, ghosts, and shadows in video streams, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 25(10), pp. 1337-1342.

[12] Prati, A., Mikic, I., Trivedi, M.M., and Cucchiara, R., (2003). Detecting moving shadows: Algorithms and evaluation, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 25(7), pp. 918-923.

[13] Cho, J.H., Kwon, T.G., Jang, D.G., and Hwang, C.S., (2005). Moving cast shadow detection and removal for visual traffic surveillance, *Ai 2005: Advances in Artificial Intelligence*, vol. 3809, pp. 746-755.

[14] Kumar, P., Ranganath, S., Huang, W.M., and Sengupta, K., (2005). Framework for real-time behavior interpretation from traffic video, *IEEE Transactions on Intelligent Transportation Systems*, vol. 6(1), pp. 43-53.

[15] Luo, X.Z. and Bhandarkar, S.M., (2005). Real-time and robust background updating for video surveillance and monitoring, *Image Analysis and Recognition*, vol. 3656, pp. 1226-1233.

[16] Reulke, R., Boerner, A., Hetzheim, H., Schischmanow, A., and Venus, H. (2002). A sensor web for road-traffic observation. *Image and Vision Computing, New Zealand 2002*, pp. 293–298.

[17] Klein, L.A., M.R. Kelley, and M.K. Mills, Evaluation of overhead and in-ground vehicle detector technologies for traffic flow measurement. Journal of Testing and Evaluation, 1997. 25(2): p. 205-214.

[18] Ernst, I., et al., New approaches for real time traffic data acquisition with airborne systems, in TRB Transportation Research Board. 2005: Washington.

[19] Light, D.L., The New Camera Calibration System at the Us-Geological-Survey. Photogrammetric Engineering and Remote Sensing, 1992. 58(2): p. 185-188.

[20] Grussenmeyer, P. and O. Al Khalil, Solutions for exterior orientation in photogrammetry: A review. Photogrammetric Record, 2002. 17(100): p. 615-634.

Authors:
Sascha Bauer
Thomas Döring
Frederik Meysel
Prof. Dr. Ralf Reulke
Deutsches Zentrum für Luft- und Raumfahrt, Institut für Verkehrsführung und Fahrzeugsteuerung
Rutherfordstraße 2, 12489 Berlin, Phone: +49 30 67055 (409, 232, 285, 518), Fax: +49 30 67055 283
E-mail: (Sascha.Bauer, Thomas.Döring, Frederik.Meysel, Ralf.Reulke) at dlr.de